

PURPOSE

To investigate the periodic variation of density and solubility of compounds.

BACKGROUND

When the elements are arranged in order of increasing atomic number, they exhibit a periodic recurrence of properties. This fact led to the grouping of elements as seen in the periodic table. Elements in vertical columns of the periodic table form groups (families) with similar physical and chemical properties. These similarities are due, in large part, to the fact that all the elements within a group have the same outer-shell electron configuration. You can also find periodic trends in certain properties, such density, among the elements within a given group. In addition, compounds that contain elements from the same group can display trends in properties such as solubility.

In this experiment, you will investigate the variation in density among certain Group 4A elements and the variation in solubility for salts of Group 2A elements. You will use your results to predict the density of another Group 4A element and to identify an unknown Group 2A cation.

SAFETY FIRST!

In this lab, observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the procedure, refer to the list below for its meaning.



Caution: Wear your safety goggles. (All steps.)



Caution: Sulfuric acid is corrosive and can cause severe burns. (Step 3.)



Caution: Soluble salts of barium, strontium and chromium are extremely toxic and irritating to the skin. Avoid skin contact with these chemicals. (Steps 2–10.)



Note: Return or dispose of all materials according to the instructions of your teacher. (Steps 4, 6, 8, 10.)

Note: Wash your hands thoroughly after completing this experiment.

PROCEDURE

As you perform the experiment, record your data in Data Tables 1 and 2.

Part A. Densities of Group 4A Elements



1. Determine the densities of the tin (Sn), lead (Pb), and silicon (Si) samples by the water displacement method described in Experiment 4. Record the data in Data Table 1. Note the appearance of these elements.

MATERIALS (PER PAIR)








safety goggles
centigram balance
4 small test tubes or 1 spot plate
1 test-tube rack
1 plastic wash bottle
1 50-mL graduated cylinder
1 dropper pipet
lead shot, Pb [T]
silicon, Si
tin, Sn
0.1M magnesium nitrate,
Mg(NO₃)₂
0.1M calcium nitrate, Ca(NO₃)₂
0.1M strontium nitrate,
Sr(NO₃)₂ [T]
0.1M barium nitrate,
Ba(NO₃)₂ [T] [I]
1M sulfuric acid, H₂SO₄ [T] [C]
1M sodium carbonate, Na₂CO₃
1M potassium chromate,
K₂CrO₄ [T] [C]
unknown salt solution [T] [I]
distilled water

Objectives

- Measure the densities of certain elements in Group 4A.
- Measure the solubilities of certain salts of Group 2A elements.
- Describe periodic variation in the density of elements and solubility of compounds.
- Predict the density of an untested Group 4A element.
- Predict the solubility of an unknown Group 2A salt.

Part B. Solubilities of Salts of Group 2A Elements

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2.  **CAUTION:** Soluble salts of barium and strontium are extremely toxic. Add 1 mL (20 drops) of $\text{Mg}(\text{NO}_3)_2$ solution to a small test tube. Add 1 mL of $\text{Ca}(\text{NO}_3)_2$ solution to a second tube, 1 mL of $\text{Sr}(\text{NO}_3)_2$ solution to a third, and 1 mL of $\text{Ba}(\text{NO}_3)_2$ solution to a fourth.
3.  Add 1 mL (20 drops) of 1M H_2SO_4 to each tube to provide sulfate ions for reaction with the Group 2A metal ions. If the salt (MgSO_4 , CaSO_4 , SrSO_4 , or BaSO_4) is insoluble in water, a precipitate will be formed. Record the solubility of each metal sulfate salt in Data Table 2 using the following letter codes: S = soluble, I = insoluble.
4.  Dispose of the materials in the test tubes as directed by your teacher. Rinse the test tubes with distilled water.
5. Repeat Steps 2 and 3, using 1M Na_2CO_3 in place of 1M H_2SO_4 .
6.  Dispose of the materials in the test tubes as directed by your teacher. Rinse the test tubes with distilled water.
7.  **CAUTION:** Chromates are both toxic and irritating. Repeat Step 2 and 3, using 1M K_2CrO_4 in place of 1M H_2SO_4 .
8.  Dispose of the materials in the test tubes as directed by your teacher. Rinse the test tubes with distilled water.
9. Obtain an unknown salt solution from your teacher. The solution will contain ions of a Group 2A metal. Perform the solubility tests to identify the unknown ion. Treat the unknown as if it were toxic and irritating.
10.  Dispose of the materials as directed by your teacher.

OBSERVATIONS

DATA TABLE 1: DENSITIES OF GROUP 4A ELEMENTS				
	Sn	Pb	Si	C
mass of metal (g)				
volume of water alone (mL)				
volume of water + metal (mL)				
volume of metal (mL)				
density of metal (mass/volume)				
appearance				

DATA TABLE 2: SOLUBILITIES OF SALTS OF GROUP 2A ELEMENTS			
	SO_4^{2-}	CO_3^{2-}	CrO_4^{2-}
Mg^{2+}			
Ca^{2+}			
Sr^{2+}			
Ba^{2+}			
unknown			
unknown # _____ identity of cation of unknown _____			

Analysis and Conclusions:

Part 1: Density

1. Prepare a graph of density versus period number for carbon, silicon, lead, and tin. (Be sure to include all appropriate labels)
2. Based on your graph, predict the density of germanium. Compare your estimate with the accepted density of germanium (5.46 g/cm^3). Give possible source of error.
3. Calculate the percent error between your estimated value and the accepted value of the density of Ge.

Part 2: Solubility

1. Describe any relationship you see between the solubility of salts containing alkaline earth metal ions (group 2) and their position within the group.
2. Based on the data, you may not have been able to identify the unknown group 2 ion. Why?